Addendum to BSAI King and Tanner Crab Plan Team Meeting Minutes
22-24 September 2003

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4 October 2003

Forward:
The limited time schedule following the Crab Plan Team meeting did not allow opportunity for review and comment of meeting minutes by team members. The material in this addendum would be inserted on p.5 before the 4th full paragraph beginning with "After discussion, ...". While it has been distributed, this addendum similarly has not benefitted from review and comments by team members. The responsibility for its contents rests with the author.

Upon opening the discussion topic of *Overfishing Definitions and Fisheries Management Plan*, Lou Rugolo was asked by the CPT Chairperson to discuss technical limitations with the BSAI King and Tanner Crab plan including overfishing definitions. The following is an annotated outline of the points addressed:

1. The definition of 'overfishing' and 'overfished' in the plan:
   There's inconsistency in the FMP and Amendment #7 concerning these definitions.
   a. The Sustainable Fisheries Act requires that overfishing status criteria must specify both a maximum fishing mortality threshold and a minimum stock size threshold. Stocks are assessed as to whether the maximum fishing mortality threshold is exceeded and to whether the stock is below the minimum stock size threshold.
   b. SFA states that overfishing is occurring if the fishing mortality rate [F] exceeds that required to produce maximum sustainable yield [MSY] on a continuing basis.
   c. SFA states that a stock is overfished if its biomass is below the level required to produce MSY on a continuing basis.
   d. The BSAI King and Tanner Crab plan defines an 'overfishing' threshold based on a fishery catch standard defined as Sustainable Yield [SY].
   e. This SY standard is derived in a manner that is inconsistent with the SFA 'overfishing' and 'overfished' standards. [see Items 10, 12 and 13]. It's application is also theoretically incorrect.

2. The MSY control rule of the BSAI King and Tanner Crab FMP:
   The FMP states:
   "MSY control rule ... is the mature stock biomass ... exploited at a fishing mortality rate equal to ... natural mortality. Overfishing is defined ... as any rate of fishing mortality in excess of the maximum fishing morality threshold, F_{MSY}. The maximum fishing mortality threshold [MFMT] is defined by the MSY control rule, and is expressed as the fishing mortality rate. The MSY fishing mortality rate $F_{MSY}=M$."
   a. As above, the MFMT is defined by the control rule as a fishing mortality rate F, and is set equal to $M=F_{MSY}$.
   b. Amendment #7 supercedes this definition, and defines 'overfishing' based on a fishery catch standard SY computed by [$SY = TMB * F_{MSY}$].
   c. This latter definition lacking.
      i. SY is not computed on the exploited portion of the stock.
      ii. TMB includes mature female biomass which is not a component of fishery landings.

iii. TMB includes mature males of smaller size than the effective minimum size limit, and of male shell condition which are not a target of the directed fishery or main component of yield.

d. The SY catch standard is inconsistent with the plan's MSY control rule [above] and with the SFA which specifies overfishing in terms of a rate of fishing mortality F_{MSY} in excess of M.

e. Application of the Amendment #7 catch standard-based overfishing definition results in exploitation rates in excess of F_{MSY} on the exploited stock [see Item 13].

3. Co-application of instantaneous fishing mortality rate [F] and annual exploitation rate [u]:

Lack of specificity in FMP allows F and u to be used interchangeably in computational formulae.

a. The annual rate of exploitation [u] corresponding to a target F rate [e.g, F_{MSY}] is:
$u = F * [1 - e^{-(F+M)}] / (F+M)$ where M and F co-occur.
$u = 1 - e^{-(F)}$ where M and F don't compete [e.g., pulse fisheries].
Using the instantaneous rate of fishing mortality [F] in computational formulae requiring the exploitation rate [u] results in substantial overestimation of the allowed target u rate and in the corresponding harvest quotas.

b. The fully recruited rate of fishing mortality F and the fishery selectivities should be employed in and amended overfishing definition to avoid confusion as to
i. the proper exploitation rate to use.
ii. what is the exploited stock in question.

4. Application of F_{MSY} is inconsistent with its definition:

a. F_{MSY} is a yield-based type of biological reference point [brp] and does not pertain by rule to, or is based on exploiting the mature component of a stock @ $F_{MSY}=M$.

b. Other brps are designed to conserve a certain fraction of mature stock biomass. For example,
i. $F_{\%MSP}$ - the equilibrium fishing mortality rate which would conserve a fixed percentage of the maximum spawning potential of a stock on a SSB/R basis.

c. In contrast, the FMP overfishing definition is the catch standard [SY] computed as $TMB*F_{MSY}$. This is not equivalent to fishing a stock at F_{MSY}.

d. The catch standard should be derived using the exploitation rate corresponding to F_{MSY} as: [u_{MSY} * ESB], where ESB is the exploitable component of stock biomass, which must also consider discard losses.

5. Baranov (1918) Catch Equation mis-specified:

The catch equation $C=F*A/Z$ is incorrectly applied in setting the catch standards - hence, in setting the operational overfishing definitions of the plan. This results in underestimation of realized exploitation rates, and in overestimation of preseason harvest goals.

a. Exploitation rates are calculated on survey biomass which is the maximum biomass defined at the start of the 'biological' year estimated at the time of the survey. This is not average stock biomass over the year required by the catch equation if F is used as a factor instead of u.

b. In this application, losses from the stock due to natural mortality from the start of the biologic year to the fishery are unaccounted. This results in overestimation of the exploitation rate corresponding to target $F_{MSY.}$

6. Discard mortalities not properly incorporated into harvest rates:
   a. In some cases, discard mortalities are estimated in harvest strategy models as part of M. Losses from the stock due to discards from the directed fishery, or from non-directed bycatch are improperly assigned to the intrinsic rate of natural mortality [M] of the species.
   b. Such models are intended to translate the overfishing definitions in the FMP to total direct and indirect removals from the stock that correspond to the target F_{MSY} rate.
   c. Lack of incorporation of these losses results in overestimation of the target u rates and allowed harvest quotas.

7. The values of instantaneous rate of natural mortality M specified in the plan:
   They are inconsistent with the life-history of these species.
   a. They are overestimated resulting in biologically risk-prone outcomes in terms of target or threshold F rates, or the corollary exploitation rates.
   b. Current estimates are based on a method [Hoenig 1983] for estimating Z for lightly exploited stocks using observed mean oldest age [t_{MAX}] in the stock. The method was not applied to crustaceans or to virgin populations.
   c. Current practice in ICES for estimating M, and as adopted in other Federal fishery management plans, was standardized using Anthony [1982].
   d. Application of Hoenig [1983] overestimates M to be 40% compared to the ICES method across the range of maximum ages corresponding to longevity. When used to derive overfishing definitions based on target fishing morality rates, this difference provides more risk-prone management outcomes.

8. Annual estimates of M are not integrated in the overfishing definitions in the plan.
   a. Instantaneous natural mortality rate is decoupled from the MSY control rule.
   b. In some cases, M is estimated annually by simulation models effectively as a 'catch basin' variable for all stock losses not attributed to direct fishery removals.
   c. Estimates of M can exceed that specified in the overfishing definition of F_{MSY} without modification of the target F_{MSY} or MFMT goals.

9. Concept of Z_{MSY} not addressed by plan overfishing definition.
   a. The instantaneous rate of total annual mortality [Z] is defined as M + F, where F should include all direct and indirect losses.
   b. Estimates of F_{MSY} are customarily an emergent property of theoretical population dynamic modeling whose value depends on the specified input M. If the value of M changes so would the value of F_{MSY}.
   c. While we accept that M may change inter-annually, or may be age or size-variant, empirical studies are commonly lacking to provide such understanding.
   d. The principle embodied in the Magnuson-Stevens Act of fishing at F_{MSY} is that, given a value of M specified for the species, the plan will define conservation and management measures to maintain total annual losses at or below the sum of $F_{MSY} + M$. Hence, at or below $Z_{MSY} = F_{MSY} + M$.
   e. The overfishing definitions in the plan allow M to be estimated annually in excess of that specified, while the harvest quotas are estimated using the full F_{MSY}. That is, declines in abundance measured by the survey and unattributed to the retained catch, are assumed to result from assumed increases in M.

f. By such application, the realized Z is allowed to exceed Z_{MSY}, often dramatically, without meeting the overfishing test standard of the plan or the intent of the 'overfishing' test standard of the SFA.

10. Sustainable Yield [SY] as computed, and established as the 'overfishing' definition is theoretically incorrect.
    a. The SY in any year, or MSY for a stock, in theory results from the population's inherent production characteristics.
    b. SY is meant to represent a measure of stock production which can be removed in excess of that necessary to provide stock replacement. It is often based on long-term dynamic equilibrium theory.
    c. The Bering Sea crab stocks under plan management have not demonstrated the ability to replace total annual losses or to maintain themselves in equilibrium. Instead, stocks have fallen and remained at exceedingly low levels of biomass.
    d. Stock remaining at these dramatically depressed abundance levels, often for decades after fishery closures, implies that they may have fallen to levels below their compensatory reserve.

11. B_{MSY} for each stock is defined as the average annual survey-based estimated TMB for the 15-year period, 1983-97.
    a. The principal BS crab stocks were not in dynamic equilibrium with their environment during this period. Instead, they illustrated significantly, systematic declining trends in overall abundance.
    b. They were at levels of stock biomass which would not provide maximum sustainable yield [MSY] by definition.
    c. Computing benchmarks of B_{MSY} or MSST [= ½ B_{MSY}] using this 15-year time period underestimates threshold levels of stock biomass used to define the overfished test standard, or the overfishing standard as applied in this plan.
    d. These arithmetically lowered stock thresholds result in more risk-prone outcomes in terms of judging stock health, stock recovery or overfishing.

12. A conceptual mismatch exists between the stock component used to estimate annual harvest goals and the component of the population exploited by the fishery.
    a. As noted, harvest goals are estimated using TMB which includes all mature animals of all sizes, both sexes, and all shell conditions.
    b. The fishery exploits only a segment of the male stock, and not females directly. Because of market constraints, it also principally retains only new shell (SC2) animals, not SC3-5 crab even if of legal size. This results in removals from the vulnerable stock at rates of F in excess of the F_{MSY} target set as the overfishing definitions in the plan [$F_{MSY} = M$].
    c. Furthermore, the TMB estimate is computed using animals throughout the Bering Sea geographic range of the species.
    d. Many of the Bering Sea crab fisheries operate in a portion of this range thereby exploiting local stocks disproportionately at F > target F.
    e. With opilio, for example, the fishery mainly exploits local stocks in the southern / eastern [of 173° W. Longitude] for practical considerations. It does not fish randomly across the range distribution from which TMB is estimated.

f. This leads to high rates of exploitation born by specific segments of the stock and to localized depletions. Changes in spatial distributions of BS opilio over time demonstrates the clearly.

13. The application of the MSY control rule for determining overfishing based on whether harvest exceeds SY is inconsistent with the definition of overfishing.
An illustration of this inconsistency was presented using the 2003 survey estimates of biomass and abundance for snow crab.

The 2003 overfishing standard for C. opilio per Amendment #7 and illustrated in the SAFE:
a. TMB in 2003 = 306.2 million pounds.
b. SY would be 306.2 million pounds * F_{MSY} [0.30] = **92 million pounds**.
c. So, if the retained catch is < 92 million pounds, overfishing is not occurring by this plan's definition.
d. The 2003 survey estimated 65 million male opilio in the stock ≥4" of all shell conditions [SC2-SC5].
e. At 1.27 lbs/individual [used in GHL calculation] = **82.6 million pounds**.
f. Thus, the applied MSY control rule would allow every male ≥4" in the population to be taken by the fishery [since 82.6 < 92 million pounds] without meeting the overfishing threshold standard of the plan. That is, u = 100%, F = ∞.

14. Two additional plan elements were proposed to be included in the plan amendment:
a. A Limit Reference Point [LRP] System [Caddy 1998] for gauging the annual status of the stocks [sos].
    i. Caddy's 'Traffic Light System' is an approach for identifying and enumerating meaningful indices of stock status. These are evaluated annually so as to derive an aggregate index of stock health.
    ii. This method was proposed to replace the existing single point comparison of where current stock biomass is relative to the MSST = ½ B_{MSY} threshold [see Item 11].
    iii. Several classes of LRPs were discussed for illustration.
    iv. Annual sos determination would be based on the aggregate index of stock health which would provide guidance in the harvest setting process.
    v. Target vs. limit reference points were discusses, and their use in an overfishing control rule to define a 'F Buffer Zone' between the 'F Target Zone' and the 'F Overfishing Zone'.
b. A Tier System for prescribing maximum fishing mortality threshold [MFMT] rates as adopted in the BSAI Groundfish FMP, with modification.
    i. The Tier System in the Groundfish plan corresponds to orders of information availability. With the exception of lesser BS crab stocks, the order of information on the principal stocks is comparable and should enable estimates of thresholds corresponding to the top tiers in the groundfish plan.
    ii. It was proposed to merge the Limit Reference Point System and the Tier System so as to derive MFMT values that reflect the current health and status of the stocks.
    iii. The combined systems would be useful in terms of revised overfishing definitions, and for advising appropriate F_{OFL} values.